RESEARCH ON SURFACE FINISH

Preliminary Report by the Research Department of the Institution of Production Engineers

(Prepared by the Director of Research, Dr. Geo. Schlesinger).

AN important property of any machine part is the nature of its surface. While it is essential to have suitable material, correct dimensions and proper heat treatment, it is equally important to have a surface finish which facilitates the proper functioning of the part with the required pressures, speeds, etc.

The best form of surface for any component will depend upon the results required—e.g., reduction of friction. or increase of life, and also upon the materials to be used. The finish should be just " good enough " to allow the component to function satisfactorily and also to permit economic manufacture.

Surface finish has an important influence on the resistance of the components to wear. Undue wear wastes money, and wear is to a great extent controllable by attention to surface quality. Without finish control, the investment in machines and tools to produce accurate size is endangered. Good surface finish is easy to attain and the costs are negligible compared with the benefits derived. Quality of surface rules modern manufacturing.

One of the leading motor-car manufacturing companies of the United States of America assert that their cars do not need running-in because the wearing surfaces are superfinished. They do not seal the speed box for the first 1,000 miles but allow their clients to drive from the first moment at 50 m.p.h. They state that they can superfinish the bore of a cylinder 3½ in. diameter and 4 in. long in 30 to 45 seconds, and that the process, which is not a polishing but a finish cutting operation, saves one of the final boring operations.

If this is true, the superfinishing operation is economically justified. If the surface produced is not only better but cheaper, everybody will accept this refinement.

The first task of the Research Department was to test *existing methods and instruments* and to report upon *their usefulness for production workshops.*

Objects and Methods.

The objects of this research are : (1) To replace the present loose descriptive methods of defining surface finish by a more definite

system. (2) To select a suitable unit for measuring surface finish. (3) To suggest symbols for use on drawings. (4) To compare the methods of observing surface finish.

First we have to discover what surface finishes are in use in the different branches of British industry. We must know what is understood by "good," "very good," "exceedingly good," by "commercially ground," "fine ground," "superfine ground," by honing, lapping, burnishing, polishing. Further, we must know if these terms have the same meaning in different branches of industry. Therefore, we selected the following branches: (1) Motor-car. (2) Aeroplane. (3) Railway. (4) Electrical machinery. (5) Machine tools. (6) Optical and precision instruments.

Sixteen leading British firms, selected from these branches of the engineering industries, have contributed more than 150 different components, having surfaces representative of each type of finish covered by this research. The specimens chosen were ordinary components of which we knew the material, finish and function,

Table I.—GEAR DATA.

Symbol No.	No.	Piece	Material	State	Function	Method of Machining	Kind of Finish	Measuring Unit
A	1	Rear axle worm	Steel forging	Case hardened	Worm meshing	Threads profile ground and polished	Very good	
B	1	Spur change gear	Steel	Soft	Gear meshing	Teeth cut on Fellows machine	Commercial	
C	1	Helical gear	Steel	Soft	Gear meshing	Teeth cut on Sunderland machine	Commercial	
D	1	Helical gear	Steel	Hard	Gear meshing	Teeth hand-baffled after cutting	Commercial	
E	1	Bevel gear	Steel	Soft	Gear meshing	Teeth cut on Gleason machine	Commercial	

particularly the direction of sliding—i.e., whether the surface serrations were parallel to the direction of relative motion or perpendicular to it. Table I shows how the various specimens were classified by the manufacturers.

The surfaces examined were produced by various methods of machining, including boring, reaming, turning, milling, broaching, planing, scraping, grinding, honing and lapping. The so-called "superfinished" surfaces of U.S.A. practice were not submitted by any British manufacturers. Fig. 1 shows graphs of some important machining processes.

It is necessary to know how a smooth surface looks and what are its characteristics, irrespective of its light reflecting or dispersing

qualities. It is a question of whether a ground or a lapped surface looks smoother. The two surfaces may be of the same quality or smoothness, but the serrations of the ground surface run parallel to each other, whereas the serrations of a lapped surface run in whirls. Very great variations in smoothness can be produced by grinding. Therefore, we cannot describe a surface by naming the method of

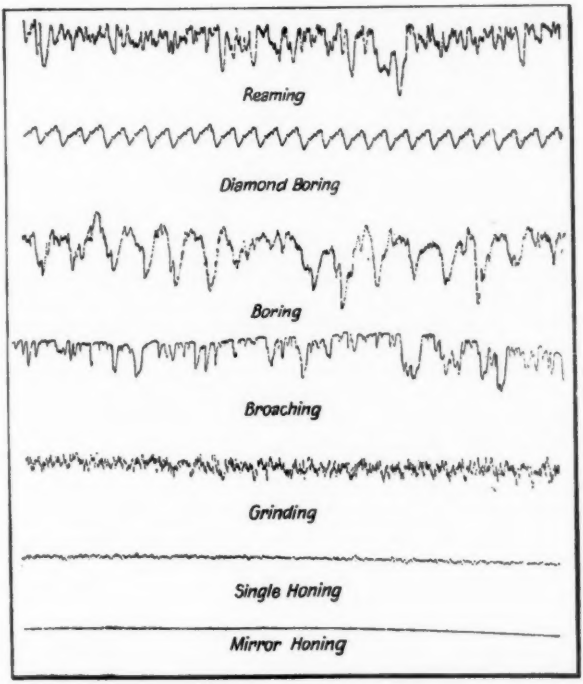


Fig. 1.—American Practice-Profilometer Oscillogramms.

producing it. The method of producing is only a means to an end. The desired surface quality is the end itself. The designation of the quality of the surface should be an absolute measurement and cannot be defined by the method used. Sight and touch judged by the unaided eye and finger depend on the personal element which ought to be eliminated if we are to succeed in arriving at a reliable standard of measurement. Therefore, turning, fine turning, diamond turning, grinding, honing, lapping or superfinishing signify a manufacturing

process but not the surface quality. It may be possible that new and more economical methods will be developed in the future.

A short review of modern finishing operations will make the situation clear. We will discuss: precision boring and turning, grinding, honing, lapping, super-finishing.

Boring and Turning. (Figs. 1 and 2).

It is necessary, in finishing a hole or a shaft, that it be of proper size, round, straight, parallel, etc. If the piece is flat, its surface must be accurate and true before starting the final finishing "smoothing" process.

The preliminary finishing processes are performed on precision boring and turning machines. Nowadays surfaces are produced by turning and boring, which show an almost perfect finish combined with extreme accuracy. We are successfully turning, facing and boring with cemented carbides and diamonds, getting a very smooth surface and satisfactory tool life, with very fine limits of 0.0001 in. For example: Pistons of aluminium alloy have been turned to a surface finish of 5 to 15 micro-inches with diamonds or hard cemented carbide tools, connecting rod bearings are being bored on precision machines to an *almost perfect finish* and to extreme accuracy.

The success of these machining operations does not depend on the tool alone, which accomplishes all the necessary requirements, but on the design of the machine tools, which must be simple, rigid, free from vibrations and of an accuracy in alignment which guarantees the above-mentioned tolerance.

As the main elements of diamond boring and turning machines are the bearings and the journals of the main spindle, which depend definitely upon the ground-finished surfaces to obtain the required size and form, such as roundness, flatness and straightness, the final grinding operation is of decisive importance.

Grinding. (Figs. 1 and 2).

Most production engineers use the grinding machine for the last finishing process.

Grinding, as a term used in production engineering is a process of removing metal or other relatively hard material in preparing the surface of such metal or material in order to obtain a desired size, shape or finish or any combination of these. Grinding uses abrasives, moulded and bonded together in the form of wheels or blocks, which are revolved or moved relative to the surface and in contact with the material to be ground with the necessary speed. Lubricant or coolant may or may not be used in contact with the work-piece and abrasive. The action of the grinding tool is one-sided, but the cutting forces are very small so that the full cylindrical shape of the workpiece is secured, with or without using steady rests.

The grinding machine in its several forms has been recognised for many years as the only acceptable standard machine tool suitable for removing an appreciable amount of stock from a piece of work and at the same time produces the required accuracy and acceptable surface finish. Further, the machine is fully automatic, in so far as

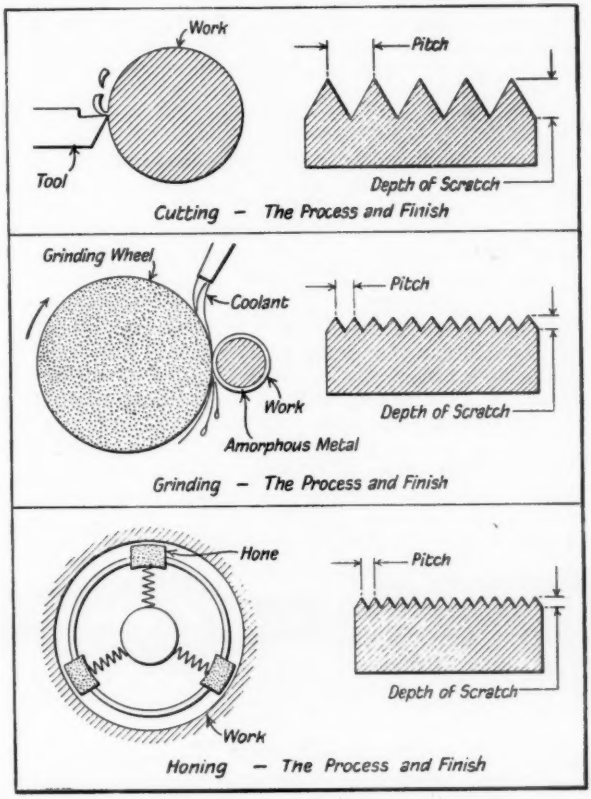


Fig. 2.—Important Cutting Processes

the machining process itself is concerned. The resharpening of the wheel is often done automatically. The adjustments of the machines are extraordinarily fine. The whole operation of the machine might be learnt by unskilled male or female labour in a

week. These are the most important reasons why the grinding machine to-day rules the finishing department. But the machine is heavy, consumes much power and the finest finish is not obtainable from it. Most important of all, the percentage of the " bearing area " of the surfaces produced is, in some cases, not great enough to stand the initial wear. This is the reason for the latest development of finest finishing operations such as honing, lapping and superfinishing, which are, however, made on the preliminary process of a well-ground surface as a basic requirement.

Honing. (Figs. 1 to 4).

Honing is a process of removing the inaccuracies left by a machining or rough grinding process. The abrasives are used in the form of square sticks or " hones " which have a very great abrasive area. This multiplicity of contacts permits low-unit stress application over a large contact with the work with the result of quicker stock removal. Lubricant is an essential medium between the abrasive and workpiece which must move at a speed relatively slow with each other comparative with grinding.

Honing combines in one process : (1) Efficient removal of stock, (2) size and bore accuracy with (3) any desired degree of surface smoothness. The honing process f.i. for the bore uses a tool (Fig. 3) with multiple cutting edges employing a large total area of abrasive material. The amount of pressure on the individual abrasive grains in honing is considerably smaller than in grinding.

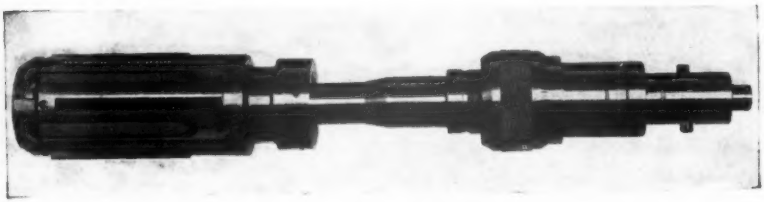


Fig. 3.—Internal Honing Tool

The path travelled by the tool comprises combinations of rotations and one or more longitudinal reverse traversing motions simultaneously. The work may also be rotated or reciprocated, or both.

The honing process ensures balanced shearing force application and eliminates the possibility of structural deformations due to quill or spindle bearing limitations.

K. W. Connor, of Detroit publishes (Fig. 4), the travel path of a stone of varying direction and rate of surface travel, to hone a bore. It combines a simple rotation and a simultaneously reversing stroke or traverse of the tool. This combined action causes the abrasive stick to follow the path of a wide angled helix of steep pitch. In many typical installations the ratio of revolutions to reciprocation is from $3\frac{1}{2}$ or 4 to 1. In the illustration the ratio is slightly more than 2 : 1 to simplify the drawing. The area of crossing of these paths on the forward and reverse strokes produces the characteristic cross

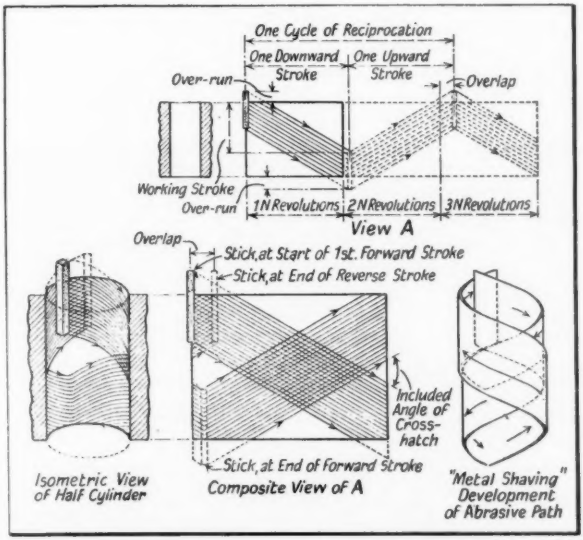


Fig. 4.—Travel path of an abrasive stick in honing is resultant of combining simple rotation with a simultaneous reversing stroke or traverse of the tool. Particles of grit or abrasive do not cut uniform helices or follow previous paths. Stone frequently cleans itself.

hatch of the honing marks. Surface speeds of abrasive travel in the honing process range from 10 to 250 ft. per minute, depending upon the material, the desired extent of stock removal and final surface finish.

The ability to control size in honing is accomplished by the regulation of the expansion of the abrasive stones in their holder (Fig. 3). This is usually arranged by having the expansion mechanism feed out to an adjustable limit stop in the tool. Accuracy for roundness is obtained by the rotary motion of the hone and the controlled,

positive expansion provided in the tool. Accuracy for diametrical straightness is produced by the reciprocation of the hone which permits the correction of taper errors. Accuracy for axial straightness is accomplished by the use of sufficiently long stones to overcome any twist generated in the bore in previous processing operations. Honing is, at present, one of the last and most perfect methods of finishing bores.

Lapping. (Fig. 5).

Lapping is a refining process of removing minute inaccuracies and/or the rough surface left by a grinding process from hardened or similar hard material by means of fine abrasive powder embedded in a metal matrix which may be in the form of wheels or flat plates. Regarding relative speeds of abrasive and workpiece and lubrication between the contacting surfaces, it is somewhat similar to honing.

Fig. 5.—Lapping Action on Valve Stems.

The primary object of mechanical lapping operations is to obtain dimensional accuracy at a lower cost than by any other commercial process. The secondary object is refined surfaces. The motion of commercial lapping machines sets up entirely different paths for abrasive mediums to travel than have been used in previous operations such as turning, grinding, etc.

There are three general types of lapping machines. The oldest employs laps of cast iron, bronze or other soft metals and a loose

abrasive usually mixed with oil. The second is a development of the first, but employs fine abrasive discs of wheels bonded with any of the several types of bonds. The third general type of lapping machine is that which employs "coated" abrasives. The coated abrasives generally used, consist of ordinary sand or refined manu-

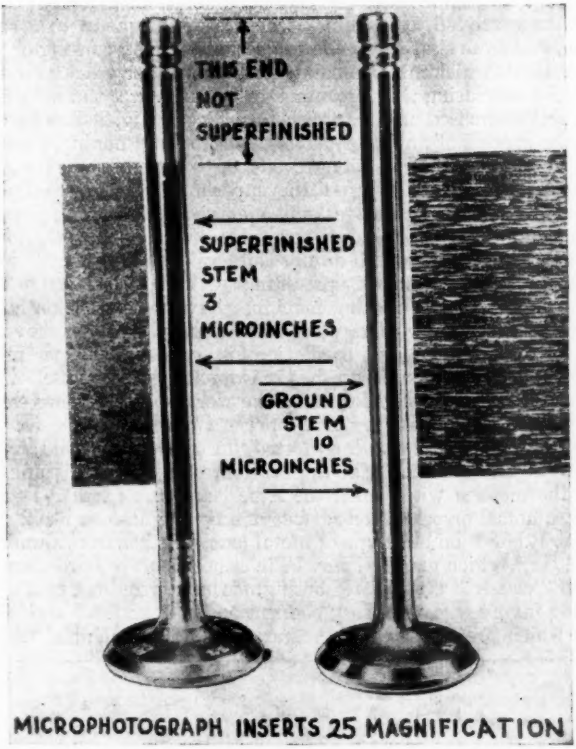


Fig. 6.—Comparison of Ground and Lapped (Super Finished) Valve-Stems. *(By Courtesy of K. W., Connor)*

factured abrasive on paper or cloth. The best applications of coated abrasives for lapping operations are for camshafts and crankshafts.

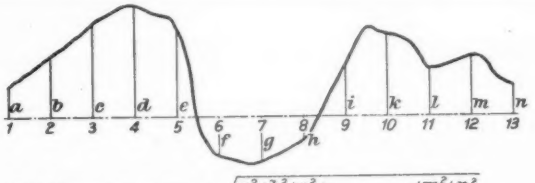
Superfinishing.

Superfinish is a name given to a special type of fine (lapping) finish, developed by D. A. Wallace with the Chrysler Corporation.

It is obtained by passing a coarse bonded abrasive stone, properly lubricated, under low pressure, slow multi-motion, over and around a flat, convex or other type of surface, the dimensions of which have been finished by preliminary turning, grinding, honing or lapping. Superfinish is said to remove the layer of free molecular amorphous metal developed on the surface by the above-mentioned methods of finishing. The removal of this layer of amorphous metal exposes the hard, undestroyed, crystalline structure of the metal to a smooth finish, free from sharp metallic projections, left by turning or grinding methods which might break the oil films under pressure in actual use. By increasing the percentage of bearing area, the wear is considerably decreased on superfinished surfaces. Fig. 2 shows graphically the process of finish for cutting, turning and honing, characterised by the sharp projections produced by one of these machining processes. Fig. 6 shows that the superfinished surface eliminates these sharp peaks and leaves only a few remaining surface scratches or defects which exist below the surface where they do no harm to the bearing surfaces and do not cause oil-film failure even with as much as double the bearing pressure.

The present superfinishing machines have an oscillation of 1 : 8, which is rather long. The work rotates and the stones move back and forth. The range of oscillations is from 1 to 20 per minute. Most surfaces can be superfinished in from 20 to 40 seconds. Wallace explains that the reason for doing the work so much more easily is because only the loose material on the surface must be removed, whereas turning and grinding destroy in cutting the solid material of the original surface. The application of superfinish is universal. It is the method with which the Americans finish either a turned, ground, honed or prelapped surface of any roughness up to 2 micro-inches, R.M.S.* on any type of metal (such as steel, iron, aluminium, brass, etc.), which material may be in either a soft or hard condition.

The " classic " methods of boring, turning, grinding, milling and planing involve a compulsory connection between feeds and revolutions which produces parallel serrations on the machined surfaces.



* R.M.S. (root-mean-square) = $\sqrt{\frac{a^2+b^2+c^2+\cdots\cdots\cdots+m^2+n^2}{z}}$

Ordinates *a*, *b*, *c*.....*m* are measured, squared, added and divided by the numbers of the ordinates (here 13), then the root is drawn. This gives a better average than the arithmetic mean.

Honing, lapping, and superfinishing create, as above-mentioned, serrations in whirls which, although machine made, are smoother than the ground surfaces and increase at the same time the percentage of the bearing area considerably.

Grinding is a method of producing better results than by turning for finish and accuracy on soft materials and as the only means on hard materials, and at essentially lower cost. Lapping has supplemented the grinding machine by improving the quality of the surface. Lapping by any of the various methods will usually produce surface finishes less than 5 micro-inches R.M.S.* Most good lapped surfaces read between 1 and 3 micro-inches. Good average grinding, however, is usually from 10 to 30 micro-inches. Diamond turning or facing on surfaces preparatory to lapping is about 10 to 50 micro-inches.

Measuring Unit and Symbols on Drawings.

If the degree of surface finish could be defined in terms of an accepted unit, it would obviously be better than the existing descriptive methods which are subject to varying interpretations. At present we have on drawings either letters such as f, (finish), ff (good finish), etc., or signs : , *etc.* (proposal of American Standards Association), etc. These symbols may call for the comparison of the surface by sight or by touch, with an existing standard surface, but however, such signs are interpreted, they are subject, in no small degree, to the personal opinion of the inspector. To eliminate this it is necessary to have a standard scale for measuring surface finish. It is desirable that the scale should be applicable to all surfaces, however produced, and that the unit should be in terms of a standard measurement such as the unit of length. With such a scale, surface finish could be defined in universally understood terms and the exact requirement for a particular purpose could be so specified that the economic waste of producing surfaces smoother than necessary could be eliminated.

The symbols on the drawing must be : (*a*) Easily understood by the ordinary draughtsman and by the operator in the workshop. (*b*) Small, so as not to clutter up the drawing. (*c*) Identified by English names or preferably by numerals. (*d*) Such that the limits of roughness and smoothness can be specified.

Other problems which can be more readily solved, when our knowledge of the exact nature of surface finishes is more complete, include the types of surfaces most desirable for specific purposes, such as life, wear, retention of lubricants, etc., and the effects of coatings such as plating, enamelling and painting.

Instruments.*

Up to the present, the ability of the eye to distinguish by *sight* and the sensibility of the fingers to distinguish by *touch* have been the most common means of estimating surface finish. Now it has become necessary to replace estimation by precise measurement of surface finish. To do this we require reliable instruments of a simple and rigid nature, suitable for use by ordinary workmen and workroom inspectors. We also require accurate instruments in the tool room for checking purposes. There are a number of these instruments on the market, either (1) optical, including microscopes, which can be used as comparators or for measuring purposes, or (2) instruments based on touch, or (3) acoustic instruments such as the phonograph.

Fig. 7.

Optical Instruments.

Microscopes show at a glance the variation of the workpiece from the standard example of the surface required. Enlarged views of

* This short description refers only to the instruments lent by British firms to the Research Department."

each surface appear side by side in one common eyepiece, with or without separation line. Such proximity facilitates reliable comparison although no actual measurement is made.

The *Busch Comparison microscope* (Fig. 7) can be used in the workshop by people not trained in microscopic work. With this instrument magnifications between 15 and 200 times are possible, using four different eyepieces and three objectives. Experience has shown that magnifications between 18 and 50 times give the best results. With these magnifications the field of view covers sufficient area of the surface under inspection to give a true representation of its form. The built-in light source ensures perfectly uniform illumination in such a way, that when examining cylindrical or

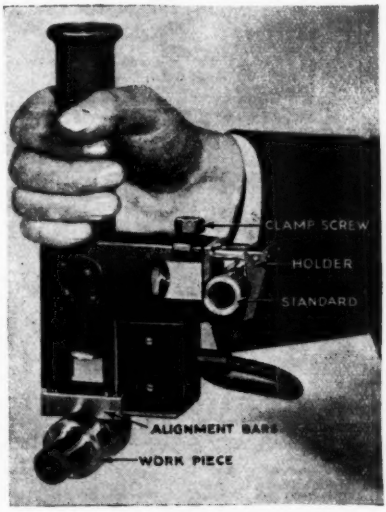


Fig. 8.

curved surfaces, they appear in the eye-piece as a flat field. Minute imperfections in the quality of the surface become apparent.

The *Higgins* (*Klemm*) *comparoscope* (Fig. 8) is a light, portable instrument specially simplified for shop use, both by the inspector and the inexperienced machine operator. A single bulb illuminates both workpiece and the standard surface. The microscope with constant magnification (26x) is so designed that it automatically focuses on either round or flat work regardless of size. The comparoscope is placed upon the surface to be compared and is pressed down until

the grooved alignment bars are in position, thus bringing the specimen automatically into focus.

The instruments are light and handy, and the inspection of the surface can be made during or immediately after machining. The method is quick and is so simple that it can be used by any intelligent employee, moreover it does not fatigue the inspector.

Another adaptation of the microscope is in the *Busch Metaphot* (Fig. 9). The specimen is placed with the surface to be inspected facing downwards on an adjustable table. Light passes through a hole in this table and illuminates the surface which is then seen through the eyepiece, or magnified on the screen below the eyepiece.

Fig. 9.

A permanent record of the surface can be obtained by replacing the screen by a photographic plate which records the enlarged image. The instrument is, in effect, an inverted microscope, similar types of which are also built in this country.* A mirror mounted in the base reflects the image on to a conveniently-placed focusing screen. The heavy cast-iron base also forms the housing for the camera.

* Comp. Vickers Projection Microscope—Cooke, Troughton & Simms-York.

The instrument can be provided with an ordinary bright field illuminator, or with the " Univertor," which permits of either bright field or dark field illumination as indicated in Fig. 10. The black figure 10a represents a perfect mirror finish on stainless steel.

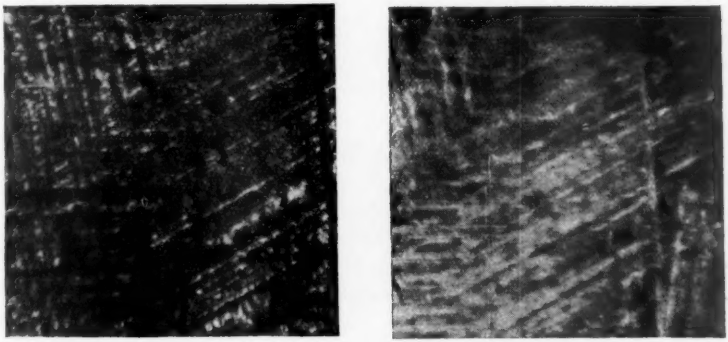


Fig. 10.—Scraped surface (cast iron).
Brightfield. Darkfield.
(Macrophoto-magnification 30 ×).

Since the camera has a fixed extension, the magnification of a photo-micrograph depends on the initial magnification of the

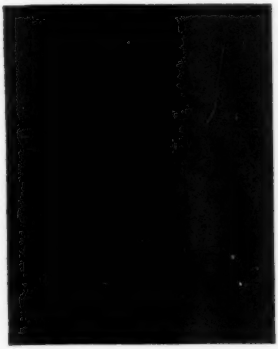
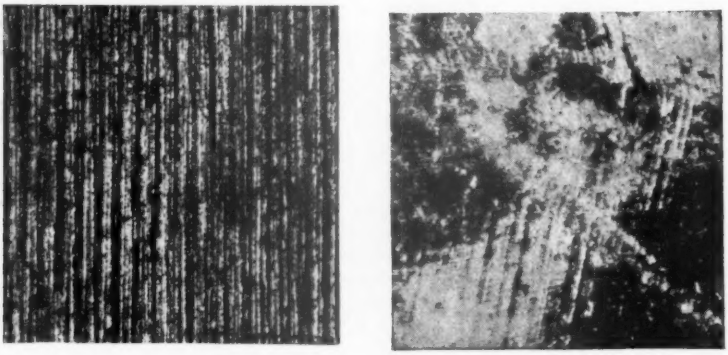


Fig. 10a.—Mirror finish on (stainless steel).

objective and eyepiece. A large number of objectives and eyepieces are available providing for close steps of magnification, between 4 and 850.

People who intend to use this instrument must learn to read photographs with considerable accuracy in order to *compare* the finished piece with the photo of the standard piece, Fig. 11. For this reason, the ordinary workman will have to depend finally on the inspector for judgment of surface finish.

An extension of this method is to have a large screen in the inspection room and to project on to it an enlarged picture of the standard surface as master, beside an equally enlarged image of the surface to be tested. There is reason to believe that the different grades of



T_1—Ground surface (Serrations). T_2—Scraped surface Criss-cross ridges. (Approx. the same smoothness comp. Fig. 21).
Fig. 11.—Macrophotos.
(Magnification 18, 5 ×).

surface finish would be so clearly distinguished that we could elaborate standards. One obvious advantage of this extension is that an inspector could easily work seven or eight hours a day, looking with both eyes at the screen, whereas with a microscope where only one eye is used, fatigue would soon cause considerable inefficiency. Another possible advantage is that once a photograph of the desired finish is obtained, it can be duplicated, thus producing as many standards as required, all of which are identical. It is not easy to produce actual pieces with such uniformity.

An important part of our investigations will be to assess the value of this method of surface inspection.

The use of the microscope in combination with a scale make it possible to *measure* surface finish—not merely to compare surfaces. Such an instrument was designed by *Schmaltz* and made by Zeiss, of Jena.

This *surface tester* consists of a microscope tube and a lighting

tube mounted at right angles to each other and each at 45° to the surface being examined (Fig. 12). The source of light is an 8-volt 6-amps. lamp, the beam being projected through a narrow slit.

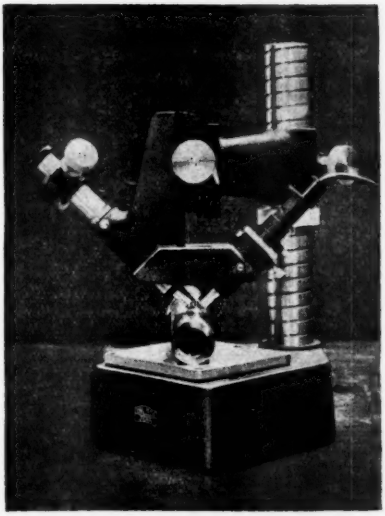


Fig. 12—Zeiss-Schmaltz Surface Tester.

Adjustments are provided for focusing the beam and the microscope. The microscope is supplied with one eyepiece and three objectives which are interchangeable.

The eyepiece for measuring the depth of the tool marks is mounted on a slide with micrometer adjustment. A hair line is set to the crests of the surface marks and is then moved by the micrometer to the roots, the displacement being noted on the graduated drum (Fig. 13).

The image seen through the microscope is an optical section of the surface of the work taken at right angles to the feed lines and at 45° to the vertical section. The actual depth of the tool marks is therefore the observed depth divided by $\sqrt{2}$. This is explained by the line drawing (Fig. 14), and by the photos of two light-bands as examples (Fig. 15).

For normal use in the inspection department the lighting and magnifying unit is mounted on a heavy column which permits rapid adjustment for accommodating work of various heights on the table (compare Fig. 12).

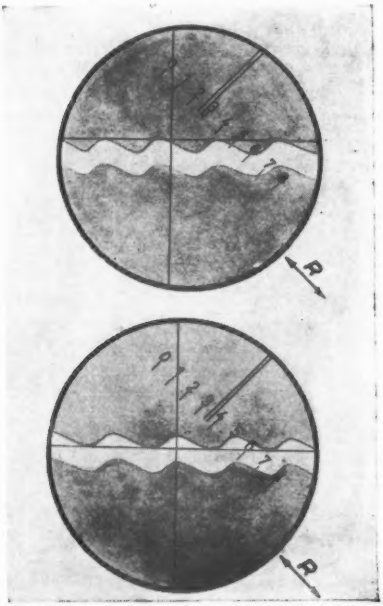


Fig. 13.—Method of measuring the height of profiles by moving the crosslines.

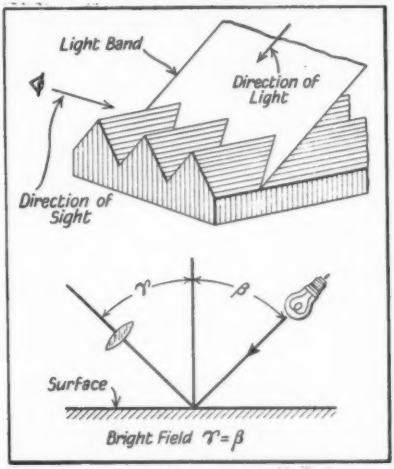
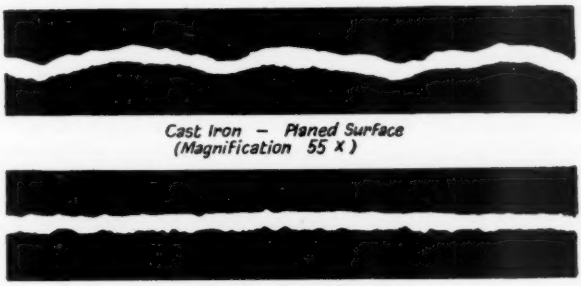


Fig. 14.—Principle of surfacemeter.



Cast Iron – Planed Surface
(Magnification 55 X)

Steel - Ground Surface

Fig. 15.—Light bands.

Fig. 16.—Profilometer in research department.

For workshop use, either on the bench or on a machine a transportable holder can be supplied. This can be used for either flat or cylindrical work.

Instruments Based on Touch.

The inspection of surface finish by *touch* is achieved either by a hand-guided feeler as in the Abbott Profilometer or by an automatically driven tracing instrument as used in the Contorograph designed by Shaw.

The *profilometer* (*Abbott*) is a portable instrument for factory use to measure and maintain final surface finish as obtained in daily production (Figs. 16 and 17). The fundamental elements of the instruments are shown in Fig. 18. The tracer method is used; the tracer support being arranged with a tiny coil which

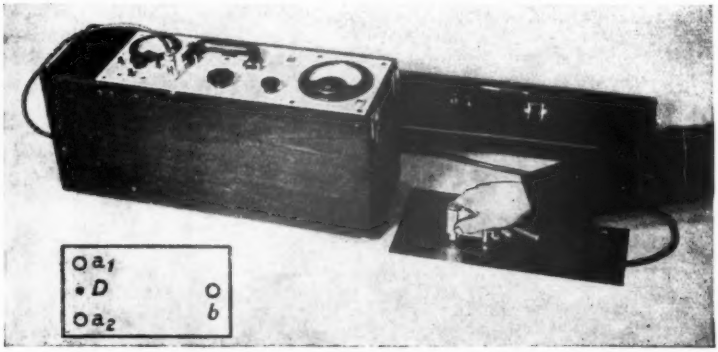


Fig. 17.—Portable profilometer with manual tracer. Left corner—Feeler Diamond D; reference plane a_1-a_2-b.

operates in the field of a permanent magnet. The tracer itself is a diamond, the shape of which is shown in Fig. 18. The movements of the tracer cause electrical oscillations which when amplified actuate a cathode-ray oscillograph which shows the magnified form of the surface undulations. In order to measure roughness, it is necessary to establish a reference plane against which measurements may be made without showing the effect of waviness. This can easily be done through the use of pilot skids which are small enough in curvature to ride up and down on the hills and valleys of the waviness, but will not sink into the smaller valleys of the roughness.

For use on surfaces in general, pilot skids which are zones of $\frac{1}{8}$ in. diameter spheres have been found to be satisfactory. For use in small holes or on surfaces with smaller radius of curvature, smaller

skids can be used as the surfaces in these places are nearly always more free from waves. The whole tracer is supported by three skids, two (a_1, a_2) in front, between which the diamond point D is set and one at the rear (*b*). The three skids always form the plane of reference and the diamond is always independent of the pressure exercised by the hand of the operator (Fig. 17, left corner).

The material for the skids is a certain type of cemented carbide which is very hard and capable of taking a high polish. The wear is negligible. At certain times it is necessary to repolish the skids, to restore the original surface, which slides easily.

The profilometer circuit may be readily adjusted to give magnifications of 3, 10, 30, 100, 300 and 1,000, times in order to accommodate varying degrees of surface roughness. The readings provided

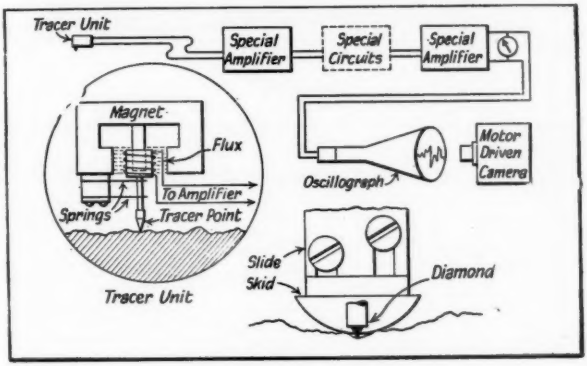


Fig. 18.—Principle of profilometer. (Below) detail of legs.

are in micro-inches, R.M.S. (root mean square) and represent a running average of the height of the surface irregularities ; the automatic averaging feature is one of the principal advantages of the profilometer. Pictorial records of surface roughness may be made by suitable synchronisation of tracer speed to film speed. For visual observation, a suitable oscillograph sweep can be used (c.f. Fig. 1).

The instrument is portable and self-contained in a convenient wooden case, weighs approximately 50 lb. and is designed and constructed for use at the production line as well as for laboratory purposes.

The instrument used in the Research Department was only made for hand measurements and the reading of the dial. In all cases 10 readings were made on the same surface, the average of which is

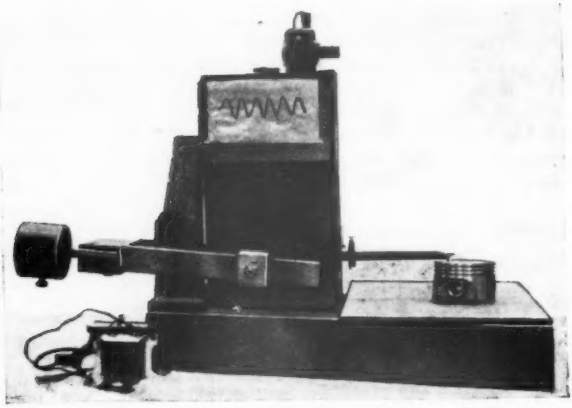


Fig. 19.

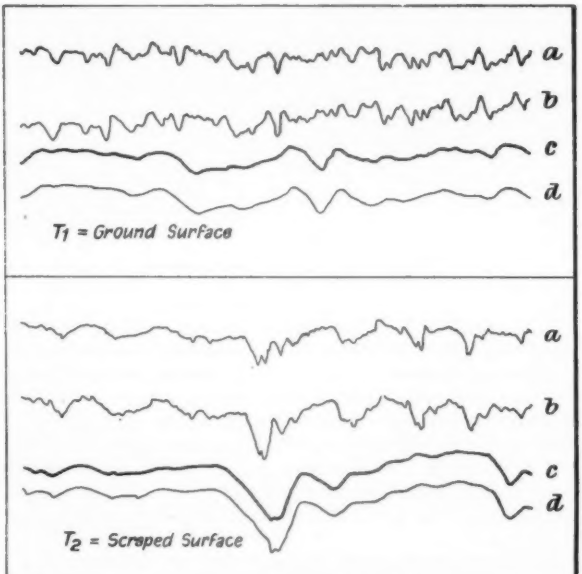


Fig. 20.

given in the report. Further, the operator and the assistant changed places so that the results should be as far as possible independent of the skill of a particular experimenter.

The *contorograph* (Fig. 19) is based on the needle and lever system. The specimen is fixed on the table while the needle is drawn over the surface to be examined. The needle, attached to the mirror lever, moves in a plane arc of a circle, rising and falling under the constant pressure of a spring which enables every detail of the vertical contour to be followed (Fig. 20). A beam of light striking the mirror is deflected up and down a sensitive paper and because the mirror,

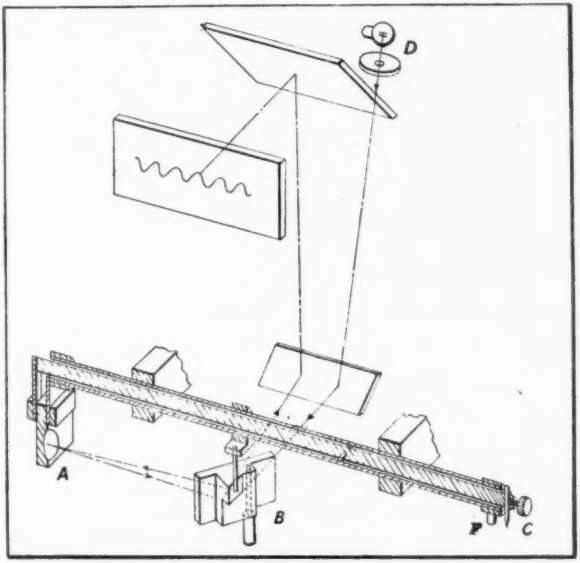


Fig. 21.—Contorograph. Diagrammatic arrangement.

lever and needle assembly move across the work, the light passes across the sensitised paper, describing the surface diagram (Fig. 21). A little stationary motor inside the case of the instrument draws the steel tube, on the under surface of which the supporting finger (F) is attached. This follows the general external shape of the specimen and guides the tube carrying the pivot round which the needle holder swivels when the tracing system passes over the specimen.

The length of the horizontal tube factilitates the entry of a bore.

The optical projection system is entirely enclosed so that the instrument can be used in the light but it is more convenient to pass it into a dark room to enable the paper or films to be extracted and developed immediately.

The motor driving the tracer arm is engaged by hand but goes out of action automatically when the diagram is finished. The horizontal speed of the tracer can be adjusted in the ratio 1 : 3. The total time of one stroke is about three minutes. The vertical magnification of the height of profile is 2,000, while the horizontal magnification varies between 50 and 150.

Experience has proved that instruments for measuring surface finish must give greater magnification in the direction perpendicular to the surface than in that parallel to the surface. The Abbott profilometer and the Shaw contorograph do this.

This review shows that we possess to-day all the necessary means, optical and mechanical, for the measurement and comparison of surface finishes. We have to make these methods economical. Methods for producing fine finishes are available and when the best methods of measuring these finishes are developed, it will be possible to define the limits of surface quality required on any component. More precise control of surface finish will lead to more accurate assessment of production costs.

The Research Department began its work early in September of this year and since then nearly 300 surfaces have been measured with different instruments. The results will be compared according to Table II.

Table II.—COMPARISON OF INSTRUMENTS.

Instrument	Method	Measuring	Units	Comparison
Profilometer (Abbott)	Touch	Dial reading	Micro-inch, R.M.S.	
Contorograph (Shaw)	Touch	Diagrams	Micro-inch, (0.000001 in.)	
Surface-microscope, (Zeiss-Schmaltz)	Sight	Microscope	Micro-inch, (0.001 mm.)	
Metaphot (Busch)	Sight	Photo		micro- and macro structure
Comparoscope (Higgins)	Sight	Microscope		Magnified comparison
Comparison-microscope	Sight	Microscope		Magnified comparison

When these comprehensive tests are finished, and all the measurements evaluate and compared according to the scheme, the result will be of immediate use in workshop practice.

Co-operation with the National Physical Laboratory.

The Director of the research department has visited and conferred with the National Physical Laboratory on the subject of this research. He has been made acquainted with the work being done there, together with the methods employed. An instrument has been developed at the laboratory which gives a numerical index of the surface finish of rolled materials such as metals and plastics. The instrument measures photo-electrically the ratio specularly reflected light, total reflected light. This ratio increases from zero for perfectly matt surfaces to unity for perfectly smooth surfaces. The two measurements necessary to evaluate the ratio occupy only a matter of a minute. It is believed that it will be possible to modify this instrument so that it may be applied to curved surfaces, internal and external. Other instruments for recording surface irregularities designed at the laboratory include one employing combined mechanical and opital magnification to give a trace of a cross-section of the surface with a magnification of 10,000. Another using a point-to-point mechanical method for measuring the roughness of journals was described in *Engineering* for 1935.*

It has been arranged that appropriate samples already checked at Loughborough shall be sent to the National Physical Laboratory for re-checking by means of these instruments. The research department will keep in close touch with the National Physical Laboratory so as to avoid over-lapping in connection with work on the subject.

The Research Department is indebted to the Works Managers and the Chief Inspectors of the following firms for sending components and for their interest and helpful suggestions : The Austin Motor Co., Birmingham ; Morris Motors, Ltd., Coventry ; Vauxhall Motors, Ltd., Luton ; Bristol Aeroplane Co., Bristol ; De Havilland Engines, Edgware ; Rolls Royce, Ltd., Derby ; Alfred Herbert, Ltd., Coventry ; John Lund, Ltd., Keighley ; Coventry Gauge and Tool Co., Coventry ; Taylor, Taylor and Hobson, Ltd., Leicester ; David Brown & Sons, Ltd., Huddersfield ; Leyland Motors, Ltd., Leyland ; London, Midland & Scottish Railway Co., Derby ; Metropolitan-Vickers Electrical Co. Ltd., Manchester ; The Associated Equipment Co., Southall.

The Director of Research also wishes to acknowledge with particular thanks the most valuable assistance rendered in connection with this investigation by the firms who loaned the instruments : Alfred Herbert, Ltd., Coventry ; Charles Churchill & Co., Birmingham ; Taylor, Taylor & Hobson, Leicester ; Gaston E. Marbaix, London ; and Klemm-Higgins, Chicago.

*Clayton, D. Engineering, 1935, *139*, 325.

THE CENTRAL REGISTER

Report of Debate in the House of Lords, Wednesday, 13th March, 1940

VICOUNT LEVERHULME, who opened the debate, said: My Lords, it will no doubt be within the recollection of many of your Lordships that over a year ago a Central Register was set up by the Ministry of Labour with the object of compiling a list of persons possessing professional and technical qualifications, so that, in the event of war, their services might be made available for Government and other forms of national service. It was one of the many steps which His Majesty's Government very wisely took when continued acts of aggression were bringing the likelihood of war nearer. I do not want to take up your Lordships' time with any detailed description of the history and machinery of the Central Register. Many of your Lordships will have seen the Classification Guide issued by the National Service Department of the Ministry of Labour. It contains just over fifty sections, embracing over 1,700 occupational classifications. It may be said to cover all the various professions and skilled occupations which can be of special service to the country in time of war. In setting up the Register, the Ministry invited the guidance of an Advisory Council of which Sir Walter Moberly was appointed Chairman. This Advisory Council in due course appointed sub-committees, and most of the sections of the Register have a selection panel, the task of these panels being to dvise on the suitability of applicants. The day-to-day work of the Register is done by officials of the Ministry of Labour.

Perhaps the first point to emphasise in regard to the Central Register is its entirely voluntary character. No person, however skilled, is obliged to put his or her name upon it or to accept any particular position offered through it. No employer is obliged to use the Register, although he is urged to do so. Government departments, however, are to some extent an exception to this rule, for we find the Minister of Labour himself, on November 16, in reply to a question in another place, saying quite clearly that "Government departments are required to use the Register to meet the staff requirements of the kind for which it caters." Of course, a Government department wanting someone not on the Register can arrange for the name of that particular individual to be placed on it. The Central Register can obviously be looked at from two points

of view. There are, on the one hand, the men and women who want to offer their services to the country and, on the other hand, there are the posts which have to be filled. In considering these two view-points we must face the clear reality that the primary purpose of the Central Register is to find people for jobs rather than to find jobs for people. That is why those in control of the Register have, very rightly, appealed to all the scientific, technical, and professional institutions to help them to get on to the books of the Register all their members with suitable qualifications.

My own personal connection with the Central Register began through my Chairmanship of the British Management Council and my being invited on that account to join the Advisory Council of the Register. The British Management Council, I may say, has affiliated to it some thirty societies and institutions concerned with business and industrial management. Those of us who have been brought into touch with the great developments which have taken place in management in the last thirty years or so are conscious that there is a substantial and ever-increasing number of persons with special knowledge in this field—men who are accustomed to approach problems of organisation from a scientific standpoint. Preoccupation with problems of capital and labour should not be allowed to blind us to the existence of this third side of the industrial triangle—management. It is a far cry indeed from the old handicraft industries of a by-gone age to the modern, vast, and complex organisations of to-day. Even during the present century remarkable changes have taken place in the structure of industry, and we can realise the enormous part which good management plays in industry to-day. Surely we must desire that experience and talent in industry, just like skilled qualifications in any other walk of life should, through the medium of the Central Register, be given the widest possible opportunity of expression.

At present that opportunity is not so wide as it might be. For instance, one would have thought that Government departments themselves, in selecting reinforcements for their administrative and executive staffs, in supplementing the grades of Principal and Assistant Principal, would have found in this field of management a useful source of supply, but those who offer their services, their management experience, through the Central Register do not find themselves placed on that section of the Register from which Government departments draw their additional staffs. I must trouble your Lordships for one moment with a small matter of detail. There are two sections involved, No. 800 entitled "Government and Public Administration" and No. 801 entitled "Business Management." It is on Section 801 that those with management experience in business and industry are placed; it is from Section 800 that Government departments draw their supplies. In times

of peace young men enter the administrative grades of the Civil Service by examination, very largely, if not entirely, from the universities, after having had a public school education. I do not wish for one moment to question the wisdom of this normal peace time method of recruitment, but in time of war the stream from this source becomes a trickle, because young men who are physically fit are needed in a different sphere. At the same time the Government departments, especially certain of them, have to expand and new Ministries are created. All this means that more and more administrative staff are required.

How are these extra people at present found? In other words, how is the list of names on Section 800 of the Register made up? Firstly, there are the retired civil servants who have come back, put on their harness again, and are giving their departments the benefit of their ripe and mature experience. That obviously is a very valuable form of recruitment. Then there are two other sources of supply lying outside the Civil Service—first, members of the teaching staffs of universities, secondly persons whose names have been put on the Register at the request or the suggestion of certain Government departments themselves. I am at a loss to understand why those whose ordinary peace-time occupation is the admittedly admirable one of teaching Latin, Greek, history, and mathematics to university undergraduates should be considered more suitable as war-time reinforcements for Government departments than those who, in business and industry, have made a special study of the technique of organisation and management and have had practical experience of it. Administration is, of course, part of the duties of many of the staffs of universities, and I do not question the high standard of ability to which many university people have attained. It seems to me, however, that this university type at present enjoys a too exclusive position on the Central Register.

I would like to take this opportunity of acknowledging the courtesy of the Minister of Labour in receiving a depuation I had the honour of taking to him last November, and also the readiness of Sir Walter Moberly, and those in charge of the Central Register, to hear, and to some extent to meet, the views which I put forward. The door has been opened a little way, but not I think wide enough to ensure the likelihood of any appreciable number of people with the type of management experience I have described finding themselves in Government departments. I would like to suggest to His Majesty's Government a departure from the present principle of separating administrative and executive appointments into groups, and to urge that all persons with administrative and executive abilities should be grouped together under one head regardless of the sections they are in at present. I would like further to suggest

that all recommendations for appointments of an administrative and executive character be made by a single panel which will in each case recommend for the post under review the most suitable persons available.

I would also like to see on this selection panel an adequate proportion of persons skilled in modern management techniques and competent to assess the qualifications of candidates whose previous experience has been industrial or commercial. I also think it would be advisable that one such person should be appointed to the Advisory Council's General Purposes Committee. I know it may be said that a great many well-known and highly qualified business men are already serving the Government of this country. Eminent names can be mentioned. Cases at once come into our minds, such as those of the noble Lords, Lord Stamp, Lord Weir, and Lord Perry, and so on. Men drawn from the board rooms and high executive positions in many business undertakings are serving the Government in various departments, but these men are there primarily because of their exceptional knowledge and experience of some particular industry, trade, or commodity, or because of their expert knowledge of some phase of the national economy. It is not men of this special character with whom I am primarily concerned. It was not really for them that the Central Register was devised.

I do not for a moment suppose, for instance, that the Chancellor of the Exchequer discovered the distinguished name of Lord Stamp by running his thumb over a card index of the Central Register, or that the name of the noble Lord, Lord Weir, was found lurking in one of its pigeon holes. No, these outstanding people require the right tools with which to work. It may be true to say that a bad workman blames his tools, but it is also true to say that a good workman must be given the most suitable tools. It is no good giving a joiner a plane when he needs a saw, or a hammer when he requires a screw-driver merely because a plane and a hammer happen already to be in stock. When men with skill in management and organisation are required it would hardly seem to be the best policy to use men with quite other qualifications, men whose normal duties have been interrupted by the war, merely because these men happen already to be on the Government pay roll. One can understand there being some resistance to the views that I have expressed. The mental approach to a problem on the part of a man trained in business is different from the normal approach of the Civil Service mind. That is at present regarded as an argument for keeping the two apart. Should it not rather be an argument for letting the one reinforce the other at a time like this? We are already spending over £6,000,000 a day. Can we at such a time afford to shut, or only partially to open, any door through which may pass into the

public service men specially trained to think in terms of simplifying procedure and of making the most economic and efficient use of time and labour ?

I have touched perhaps exclusively on this one phase of the Central Register. There are many other aspects of it which might be considered, and perhaps will be considered later this afternoon. I wonder, for example, whether in spite of what the Minister of Labour has said, Government departments themselves do know enough about the Register and realise that they are expected to use it. Then again, the Ministry of Labour has in its local employment exchanges a piece of machinery which any private employment agency might envy. The officers in charge of local labour exchanges, usually knowledgable and tactful men, have already well-established relationships with local employers, and it would seem that they might well be helpful in assisting the work of the Central Register, not only as it affects Government service but also in satisfying the needs of industries of national importance. I trust that my remarks may be considered timely, and that any criticisms I have made will be regarded only as constructive ones. I was encouraged the other day by reading a phrase which fell from the lips of Mr. Lloyd George when he said that " the last war was won by criticism." If criticism was helpful to the Government which led the nation to victory in the last war, I trust it may be no less helpful to the Government which is to lead us to victory in this war. I hope that during the course of our debate this apparently beneficial medicine may be administered by more eloquent and experienced physicians than myself.

Lord Addison : My Lords, on behalf of my noble friends I would like to support the noble Viscount and I would ask the noble Earl, the Leader of the House, to give this matter very friendly consideration. It is directed at one of the most critical parts of our administrative machinery in war-time. I know very well, from my own recollection, that if there had been a Central Register of this kind during the last war, it would have been an immense advantage. There was not a Ministry of Labour then, there was only a section of the Board of Trade, and gradually a sort of machine was built up by the experience of our troubles and our mistakes. It would have been an absolute godsend if there had been what I may call a clearing house of this kind. This Register of men with experience of business and industrial management, carefully " vetted," personally examined, and vouched for by a responsible body, provides a collection of people from whom a large number of most valuable recruits should be obtainable.

It is quite true, as the noble Viscount said, that such a Register cannot be used for the big men at the top. It is designed in order to make it possible to fill a very large number of relatively subordin-

ate but exceedingly important posts in matters of management. Cases have been reported in the papers lately which give one a very unhappy impression as to the way some people have obtained posts in the Ministries. I do not want to express any opinion on those cases because I do not know the facts, but they leave an uncomfortable impression as to how some of these posts have been filled. That is all the more reason why this Register, compiled with such care, should be fully used. I am quite sure that the noble Earl is fully sympathetic to the use of a valuable machine of this kind. I hope, therefore, that he will give a reply which will assure us that the Government intend to use this channel of recruitment, to give it real preference, and to see that it is not side-tracked by any personal influence.

LORD MANCROFT: My Lords, like the noble Lord opposite, I would ask the noble Earl to give favourable consideration to this matter. The noble Lord, Lord Addison, with his experience at the Ministry of Munitions during the last war, knows what is behind this motion. I helped in the Contracts Department in 1914 in the War Office before he went to the Ministry of Munitions, and I also know from experience what is needed in the direction of this matter. I would base my support of the plea on two grounds. Speaking in your Lordships' House about a week ago, I drew attention to the necessity of revising the method by which this Central Register is operated. I said then that I hoped its method would be improved because it would enable manufacturers to use the Register. In any case, therefore, I should wish to support the noble Viscount because he has supported me by implication in what I said last week. This matter discloses something to the Socialist Party. Members of that party talk much about capital and labour, but they always forget that there is a thing called management. Capital and labour, without management, are absolutely powerless. We have, in time of war, perfect proof of the necessity for management that is the result of skill and long training.

On one point I did not catch the exact words of the noble Viscount, but I think that what he said was to the effect that the university type occupied too great prominence. I do not think that is correct, and I say that because of a passage in a report to the Association of British Chambers of Commerce dated January 11, 1939, on the subject of the commercial employment of students with degrees in commerce. That report says:

> "Taking all this into account the deliberate annual recruitment of young graduates to commerce for the purpose of ultimately using them for the higher executive posts, must be put at a figure well below 100. These are taken mainly by large concerns engaged either in manufacturing or retailing. There is no evidence

of any appreciable recruitment to wholesale houses and shipping concerns. This low figure is confirmed by the returns from various Chambers of Commerce."

That means that most of those equipped with university degrees in economics are regarded as useless for commerce, so I should not say, therefore, that the university type occupies too great prominence. It seems to me that so far as that point is concerned, the noble Viscount based his argument on something which is not tenable.

What the Government need—and here I support the noble Viscount—are men, not directors or people on boards, or theoretical experts, or professors of economics, with text-book knowledge and without personal experience. The people wanted are those who know commercial methods, men who have had considerable experience and training in buying and selling and making contracts. This Central Register is wanted for that reason. The noble Viscount touched rather gently on the Civil Service. One does not want to speak unkindly about civil servants, but they are as a rule incompetent to do these commercial jobs. It is no good putting in war-time a home civil servant to make a contract about goods of which he had not experience previously, nor it is any good taking a retired civil servant who may have spent a good part of his working life as a Commissioner of Works in some tropical Crown Colony, and employing him in making contracts about specialised goods produced in specialised conditions. He will be wanting in initiative, he may be so old that he has lost the power to act promptly or without sending papers round to half a dozen other people for confirmation. The result is that we get nothing done except after long delay and then perhaps in a hurry under pressure at the last moment. In war-time decisions and actions must be accurate and prompt. For that reason the Government should use a Central Register when selecting staff for their own commercial purposes, but subject to this as a *sine qua non*, that the selecting committee should preferably not contain any civil servants at all. It should be composed, if possible, of two or three men who have held high managerial office in some of the great manufacturing concerns, who know themselves how to select men, who know the type of men they want for their own businesses and are capable of detecting suitable ability. If we could get that done as a result of this discussion, I think we should have done a public service, and I hope my noble friend Earl Stanhope will give attention to what has been said by the noble Viscount.

VISCOUNT ELIBANK : My Lords, I too, like the noble Lord who has just sat down, am very grateful to the noble Viscount, Lord Leverhulme, for raising this matter to-day and for the speech he has made in support of it and the explanation he has given in regard

to the Central Register and its operations ; that it does not carry the weight in the Government's councils in regard to the selection of candidates which one would have expected it to carry. I rather wish to raise the general question of policy which arises out of this motion. The Government's general policy of trade control, the effect to-day of taking over whole sections of trade, as has been done in wool, paper, copper, and any other industry you like to think of, is to bureaucratise the whole of the trading system of this country. I am not one of those who believe that you can carry on trade in War in the same way as you can carry on trade in peace, but I venture to submit that the Government have plunged into this control of the various industries in too light-heated a manner, with the result to-day that they have put out of employment huge sections of different trades which in the past relied on those trades for their livelihood.

Let us take the case of Wool Control. It is well known that in Bradford there is a Trade Control with a staff of 909. It is well known in the trade that that staff is not as expert as it ought to be. Why is it not expert ? Because it has not utilised, to the extent that it could utilise, the services of men who have been put out of work owing to the establishment of that Control. Let us take shipping. I am given to understand that it is probable that in the arrangements for the charter of ships by the Government—and the Government are taking over the whole of the charter arrangements and the whole of the merchant fleet of this country—that they will set up a separate chartering department, under a gentleman, no doubt, of experience in shipping matters. But what is going to be the effect of that ? They are going to throw out of employment a large number of shipbrokers and others who are accustomed to conduct the business which this new charter department will do. They are going to throw out of business a large number of men who have been accustomed all their lives to taking part in and conducting the charter business, and who have got considerable capital invested in those concerns. I venture to submit that that policy is quite wrong. It is not necessary. It is leading us into a state which, when the war is over, may be a very serious one indeed. But it is not only doing that. In these various Controls we are employing civil servants. I say nothing against civil servants who, as my noble friend who has just sat down said—

LORD MANCROFT : If I had thought my noble friend was going off this subject to talk about control, I should have taken a different line in my remarks. I thought we were talking only about the Central Register.

VISCOUNT ELIBANK : I cannot accept that interpolation of my noble friend, because we are talking about those industries which are being expanded for war purposes.

THE LORD PRESIDENT OF THE COUNCIL (EARL STANHOPE): No, we are not.

VISCOUNT ELIBANK: The motion says so, "to fill the requirement both of Government departments needing additional administrative or executive staff and of those industries which are being expanded for war purposes."

EARL STANHOPE: May I put it that it is the recruitment; it is not the way in which the industry is run. The whole essence of this question is the Central Register and how it should be used.

VISCOUNT ELIBANK: I will accept, for the purpose of the argument I am putting, what the noble Earl the Leader of the House says. From the point of view of recruitment, I submit that it would be very much better to employ the men who have been thrown out of work rather than civil servants who know nothing about the conditions of the departments in which they are asked to serve, who have to learn at the expense of the trade itself and of the taxpayer, and who already—I think this is a very important point—are drawing pensions, which is an unfair factor so far as those are concerned who are thrown out of employment and find themselves in poverty and very often in misery. A wiser policy of the Government would be to place first on the list those commercial men who are thrown out of employment, those men who are versed in management and administrative business experience, as suggested by my noble friend Lord Leverhulme; the services of the civil servants should come afterwards. It is for that reason that I rise to support my noble friend as well as to raise the whole issue of the policy of the Government in taking wholesale control of trade in the way in which they are doing to-day.

LORD SEMPILL: My Lords, the questions regarding the operation of the Central Register which have been raised by the noble Viscount and supported by a number of your Lordships are of great importance. It is essential for the efficient conduct of the war that as much use as possible should be made of persons of proved ability in business administration and management. One would feel that, particularly in the staffing of new Government departments, the Civil Service would be glad to have the fullest possible co-operation of trained business administrators, whose organising capacity could not fail to be of value to the nation. The Central Register, as your Lordships are aware, covers a very wide range of business and professional activities. It is to be expected that there should be much greater pressure on some sections of the Register than on others. That, as has been shown in this debate, is actually the case. For instance, there are sections of the Register where immediate use can only be made of a very small proportion of those who have volunteered to place their services at the disposal of the authorities for work of national importance. In certain other sections, however,

such for example as those dealing with engineering, there is already a very definite shortage of professional men of the kind so urgently required. This wide difference in effective demand between one section and another makes it reasonable to suppose that special measures will be adopted in the case of those shortage sections referred to which will not of necessity have to be applied to all other cases.

One of the sections where acute shortage has arisen is the all important one of production engineering, made up of works engineers responsible for manufacture and manufacturing methods. So many engineers in that section are already engaged, as your Lordships will be well aware, on work of vital national importance in firms on the priority list that the number available through the Central Register is already very restricted. Perhaps I may be allowed to ask what steps His Majesty's Government are proposing to take to meet a case of this kind? As a Past-President of the Institution of Production Engineers, in which office I was succeeded by a distinguished member of your Lordships' House, Viscount Nuffield, I have been very vitally interested in the matter. Perhaps I may inform your Lordships that the Council of that Institution have declared definitely in favour of the compulsory registration of production engineers. Their carefully considered view is that where the shortage is acute, as in that section, the voluntary system cannot be made to function fairly or efficiently. Under the present voluntary system, no one in a firm on the priority list can be approached at all by the Central Register, even for Government service; in the case of firms not on the priority list, men cannot be moved if their employers object, and in most cases they can be relied upon to object very strongly indeed if they are themselves in need of more technicians of the type that they are asked by the Central Register to release for other work.

The position is not improved by the fact that this shortage section of the Register is still open for use as an ordinary employment bureau at the service of individual companies requiring additional staff. I hope that your Lordships' House may have an assurance to-day that the machinery of a Government department such as the Central Register will not be used, at least in the case of shortage sections, for ordinary employment bureau purposes, except where men happen to be actually unemployed. In other cases its activities, I suggest, should be confined to filling Government requirements only or to finding technicians for firms where a responsible Government official certifies that the national interests require that this should be done. If I suggest to your Lordships that the voluntary system cannot function efficiently in the shortage sections, as is the case at this stage, what is likely to happen if, later on, communications are interrupted and factories are destroyed or damaged

by enemy air action? The considered opinion, as I have already submitted it to your Lordships, of the scientific body which speaks for production engineering as a whole is that the country cannot afford to run the risk of waiting until then for compulsory registration.

I very strongly urge that this matter is worthy of the most detailed and careful consideration, and I hope that when the noble Earl replies to this debate for His Majesty's Government he will give your Lordships an assurance that this whole question will be most carefully re-examined. I may mention, in connection with the work of the Institution of Production Engineers, that that work has already been advanced in a very important way by the noble Earl, acting in his previous capacity as President of the Board of Education. I happen to be one of those whom he was good enough to receive at that time, when certain important considerations were submitted to him, and I would pay tribute to the very useful service which he rendered to production engineering in this country at that time.

EARL STANHOPE: My Lords, we have had a series of interesting speeches dealing with this subject from a variety of angles, and it is perhaps, therefore, not a very easy debate to which to reply. The noble Viscount who introduced the matter fortunately eased my task by giving a description to your Lordships of what the Central Register really is, and I was grateful to him for saying that the Central Register exists not to find jobs for men but to find men for jobs. That is exactly its purpose. Similarly, I was grateful to my noble and gallant friend Lord Sempill for suggesting that where there was a shortage the business of the Central Register was only to find individuals for work in Government departments or for those firms who were really doing work of national importance. I am glad to tell him that, at any rate as regards cases where there is a shortage, as for example in production engineering, the Central Register is definitely limited to the purpose of providing people only for Government departments or for firms which are actually working on production for national purposes.

The number of persons on the Central Register is roughly 90,000. I think that the actual figure is 90,743. As the noble Viscount told your Lordships, the Ministry of Labour is assisted in choosing people from this Register by an Advisory Council under the Chairmanship of Sir Walter Moberly, and much of the work is carried out, as he told us, by committees and sub-committees. Actually, the noble Viscount himself is a member of the Advisory Council, as he is also of the Administration and Management Committee of the Advisory Council, but unfortunately they have not had the benefit of his services. He has, I understand, for one cause or another not been able to attend up till now.

LORD MANCROFT: What is the complexion of the Selection Committee?

EARL STANHOPE: It is composed partly of Government officials and partly of representatives of other bodies, as for instance the Federation of Employers' Organisations, and the Federation of British industries. There is a number of them. The panels, of course, differ according to the particular category of the actual section of the Central Register. As I understand it, what the noble Viscount is really asking is that all appointments to Government service of an administrative or an executive character should be made by a single panel on which a high proportion should be those skilled in modern management and technique. That is a knowledge which the British Management Council, of which he is Chairman, rather claims for itself, but that Council, I would tell your Lordships, is rather a new one. It was set up only, I think, in 1936 and, although he has told us that it has some thirty organisations and institutions connected with it, not all of those are of great importance, and the Management Council itself has not yet had its principles accepted by organised industry as a whole. But the point really is that the Central Register should allocate people to the posts which are vacant in Government Departments and elsewhere. That is really exactly the opposite of the way in which those posts are normally filled, and indeed are filled now.

As your Lordships who have served in Government Departments know, each Government Department selects its own recruits from those who have passed the necessary examinations and subject, of course, to the consent of the Treasury. Now what is happening is that the Government Departments notify the Central Register of the type of person they require and the type of job which it is wished to fill, and then the Central Register, through its committees and sub-committees, submit a list of names of those whom they think suitable for that post, with their qualifications and so on. Then the Government Department makes its selection from that list. I am not going to pretend that the system as it has worked in the past, or as it works now, is incapable of making mistakes. Of course Government Departments do make mistakes. They are composed of ordinary human beings and, as such, make mistakes like anybody else. But I do contend—and I am certain the noble Lord opposite and all those who have held Government office will agree with me in this—that the Civil Service of this country is the envy of the whole world, and we should be extremely careful before we change a system which has served us so admirably in the past.

I quite admit that, as some of your Lordships have said, war makes entirely new demands on Government Departments. They have to make contracts, they have to buy and sell and do all sorts of things. But when my noble friend Lord Mancroft says that a

Government Department is not accustomed to making contracts, I wonder what he knows about Government work. After all, I have served in several. I know that the Office of Works were constantly making contracts.

LORD MANCROFT: I had the privilege of helping, at Mr. Bonar Law's request, in the Munitions Contracts Department of the War Office in the late part of 1914 and onwards, and I saw then the difficulties we had to find the men who were able to do the required work.

EARL STANHOPE: That is quite another matter. What happened then is what is happening now, that you certainly had a very small Army multiplied into a very large one, and the staff which was adequate for a small Army was totally inadequate for a big one, and had to be added to enormously. Of course there were difficulties then in finding the right kind of staff to do the work, as there are now.

VISCOUNT ELIBANK: May I say that in this case you turn men out of work who are accustomed to do this kind of work, and you put in those who do not know how to do it? That is the great complaint in the City of London and in other parts of the country, where men really have been put out of work. If you put them into these Controls, and so on, it is different. The Oil Control, for instance, is manned entirely by oil people. It is working extremely well, and there is no complaint, but where you find these Departments manned by people who do not know their work, there is much complaint—and there is a great deal of complaint up and down the country.

EARL STANHOPE: I think I have heard complaints from the Party opposite—I do not say in this House—that the Government are doing exactly what the noble Lord says they are not doing—taking in people who are concerned in the industries in question, who therefore have an interest in them, and that therefore they should not be so employed. The Government do not agree with the contention of some members of the Labour Party in that respect, because we are making very large use of those engaged in industry, whether it is wool or oil.

LORD ADDISON: I hope the noble Earl does not put that contention upon the Front Opposition Bench in this House. I can never remember giving expression to any such complaint. It is much too complicated a question.

EARL STANHOPE: The noble Lord is much too wise to do anything of the kind. I only said that some of his followers, though perhaps not in this House, have done so. The noble Lord knows a good deal too much about the way in which these things have to be run. When several of your Lordships suggest that the Government are making inadequate use of business experience, perhaps I may give a few examples of what is in fact happening. In the three Depart-

ments of Supply, the headquarters office of Food, and Shipping, out of 82 temporary appointments to administrative posts (as administrative posts are defined in Civil Service appointments) 63 of those appointed had previous business experience. Of the 724 temporary appointments of executive types (excluding technical and professional posts) 712 of those appointed had previous business experience. In the Ministry of Economic Warfare, out of 180 temporary appointments of administrative type, 96 of those appointed had previous business experience, and of the remainder, the majority required professional qualifications—very largely legal qualifications—for work of the Department, and have been selected for that reason.

The noble Viscount who introduced the subject suggested that we ought to take many more men who are highly qualified by business experience and business technique, but I may point out to him that principals and assistant principals—which are the two classes of civil servants he mentioned—are junior posts and are by far the most numerous, and I very much doubt whether those who have had that kind of experience and are willing to serve in these appointments ought to be asked to accept the very low salaries attached to them. He is really thinking of men of a higher scale, specially qualified people—though I agree not so high as Lord Stamp and Lord Weir. The noble Lord opposite said that it would have been a godsend to have had a Central Register as a clearing house during the last war, and I entirely agree with him. That is how the Government are using it, and they find it most valuable, although I am bound to admit that the number of posts that have been filled from that 90,000 is comparatively small. Everybody recognises the rush of patriotic feeling which caused those 90,000 people to put their names on that Register so that the Government should have every opportunity of using their services, if they so desired. But the very large majority of those individuals are already in employment, and in very many cases in employment of very real importance—sometimes, for instance, in industries engaged in the export trade. Therefore, to ask them to fill a comparatively minor post in a Government Department would really be asking them to do a very much less national service than they are actually doing in their present jobs.

When the noble Viscount asked us that the Register should be fully used and should be given a preference, I can assure him that that is in fact the case now. I think that for practically all posts, except those which require very special technical qualifications, where there are no such individuals on the Register, the Central Register has to be used, and therefore it is indeed given not only a preference but I think almost a monopoly. My noble friend Lord

Mancroft suggested that the Selection Committee should not contain any civil servants at all. But will those who have no experience of the Civil Service and of the requirements of the Government Departments be the kind of people who are likely to make the right selection? We must all of us recognise, even noble Lords who have Socialist ideas, that when you run business in a Government Department you are under very serious disabilities, and the most serious of all is Parliamentary control. All of us know that we should, very often, employ different methods if it were not that, in order to satisfy the House of Commons and the requirements not only from the estimates' point of view, but from the point of view of publicity, we have to employ far more complicated methods than any business would dream of attempting or find at all necessary for the sake of satisfactory management. Therefore, it is necessary to know what is required of Government Departments before you can satisfactorily fill posts in them, and the only people who know what is required are civil servants. That is why civil servants are, among others, on this selection panel of the Central Register.

I do not think I can really follow Lord Elibank into the question of the Controls of industry and of raw products on the matter which is now before the House. That is really a different matter, but if he desires to have a debate on that, the Government would, of course, be ready to meet him. I can assure him that the very last thing the Government do is light-heartedly to enter upon any extra Control It is an extraordinarily difficult subject, because any of the great trades of the country are of immense complication, particularly in time of war, when questions of exchange, shipping, labour, and raw materials all have to be considered. All of these make the question difficult and complicated to deal with. Therefore, wherever possible, the Government endeavour to leave these things in the hands of private industry, as in the past. But owing to those very reasons I have mentioned, over and over again the Government have been forced to take control, otherwise there would undoubtedly be difficulties with which no private business would be able to deal satisfactorily in the national interest.

My noble friend Lord Sempill asked what steps the Government were taking to make good a shortage where one exists. The Government have that subject very much in mind. They recognise that a time may come when possibly the voluntary system will have to be, I will not say abolished or replaced by something else but, at any rate, somewhat modified, because we feel, with the national spirit what it is, we should only have to appeal to industries or individuals, asking them to come to the assistance of the Government, by taking up some work or other than that which they are doing in the national interest, to get a very full—I might almost say universal—acceptance of any demand the Government might make. That is the spirit

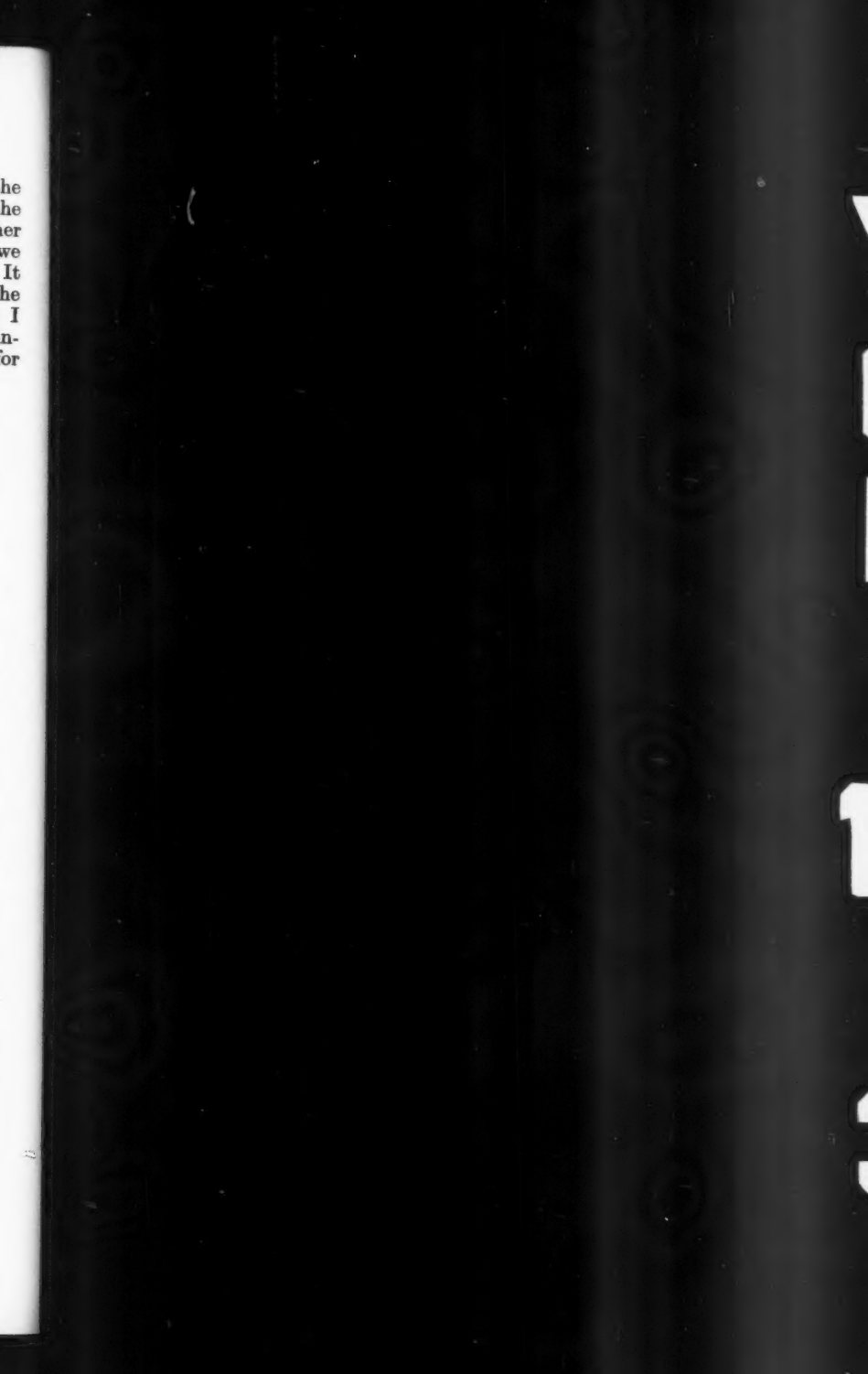
of the country among all classes and professions, and I have not the least doubt it would work in that direction as in others. I do not think there is any more I can say. I hope I have satisfied the noble Viscount to some extent that the Central Register is endeavouring to make use of those who have placed their names upon it to the best possible advantage, and I hope he himself may find more opportunity than he has done in the past to attend meetings of the Advisory Council. Then he may find that the Advisory Council is perhaps not quite so black as it has been represented to him to be, and that it is actually carrying out its work apparently satisfactorily.

VISCOUNT LEVERHULME: My Lords, I should like to thank the noble Earl the Leader of the House for the reply he has given on behalf of His Majesty's Government, I should also like to thank those noble Lords who have supported my views and those who, in various ways, have thrown light on the subject.

There is just one point in the noble Earl's reply to which I wish to refer. He expressed the hope that I might be able to attend meetings of the Advisory Council more regularly. To the best of my knowledge, the Advisory Council has not been called together for a very long time—not, in fact, since the outbreak of war. On the first occasion I was summoned to a meeting, if my recollection is right, I was ill with influenza, the second time I was abroad, the third time there was a really valid reason why I could not attend, and in each case they kindly allowed me to send a deputy.

EARL STANHOPE: I hope the noble Viscount will not think I was accusing him of not attending when he could. I recognise that there were difficulties.

VISCOUNT LEVERHULME: I am also under the impression that, as regards the sub-committee which deals with the management and administrative section, the British Management Council is represented on that sub-committee by a person other than myself. I shall certainly look into it, and endeavour to find a remedy for any defects I may have shown in this matter. May I say, with regard to the reply, that I suppose it can rarely happen, when one rises, as I have done, to move a Motion in your Lordships' House on this somewhat contentious matter, that he finds all his points met. I confess to enlightenment on many points of detail, without admitting conversion on matters of principle. There is just one point in the speech of the noble Lord, Lord Mancroft, on which I should like to touch. That was where he referred to the "university type." I fear that, perhaps, in using the words "university type" I did not choose the best phrase possible. What I had in mind was not people who have been to universities, but more particularly those who may have been on the teaching staffs of universities, university dons and university lecturers. I can speak with some

personal knowledge of the increasing value of graduates from the universities who have come into business and industry through the appointments boards of Oxford and Cambridge and all the other universities with which we are equipped to-day. The debate we have had is ample justification for the Motion I have tabled. It is a matter of great public interest. If I had any doubts about the feeling of public interest, they were dispelled by the post-bag I have had since the Motion became news in the papers at the beginning of this week. I should like again to thank the noble Earl for his reply, and beg leave to withdraw my Motion.

Motion for Papers, by leave, withdrawn.